



Feeding 10 billion people **Plant breeding and innovative agriculture**

Spread and implementation of existing knowledge, technology and best practice, and investment in new agricultural science innovation and production system approaches are needed to produce more food in a sustainable way. Overall objective is the contribution of European food production to feed the increasing population worldwide. Sustainable intensification should be reached by:

- > reducing the yield gap through improving crop production management,
- > increasing the yield potential by plant breeding, and
- > reducing crop losses.

For these objectives, this study has worked out options for action.

Sustainable intensification in the European Union

Sustainable intensification should consider the very different settings of European farming systems. In consequence, different priority tasks should be talked parallel:

- > Increasing input use efficiency especially in intensive production systems to improve their environmental performance and to maintain their production potential;
- > Increasing productivity in extensive production systems without compromising their environmental services;
- > Including marginalised farmers (e.g., semi-subsistence farming) in productivity improvement to preserve their contribution to food supply and for accompanied social and environmental benefits.

Overall, a stronger focus on maintenance and enhancement of soil fertility and exploitation of agro-ecological mechanism should be taken to stabilize achieved high yield levels in favourable areas, to realise more of existing yield potentials, and to increase the resilience of farming systems. Efforts should be undertaken to explore combinations and mutual benefits between input use efficiency and soil fertility improvement approaches (e.g., precision agriculture and conservation agriculture).

Recent scientific and technological advances and practical experiences offer significant new opportunities to address challenges of crop production in Europe. Sustainable intensification and food security at global and European level demand long-term action. Major steps to enable a contribution of the European agriculture to increasing food production are:

Building awareness

Sustainable intensification needs political commitment at European and Member State level, supported by informed dialogue with farmers and other stakeholders.

More public research funding

After decades of de-investment in public agricultural research, more public money (EU and Member States) is required, in addition to existing research spending. Sustainable intensification will often need specific measures (e.g., public research programmes) to incentivise research that produces public goods and longer-term results.

Prefer system approaches

Crop production systems approaches should be in the centre of research activities. Single technologies and practices promise only restricted advances. Approaches that combine different technologies and practices will produce real progress. Research communities should open up, and mutual learning should be encouraged between precision agriculture, conservation agriculture, organic farming, agroforestry and integrated crop-livestock system research, based on common points in objectives and practices.

Enable long-term projects

Long-term agronomic research projects at both farm and research levels throughout the EU are needed because the impacts of greater shifts in crop production (such as with conservation agriculture, organic farming, agroforestry and integrated crop-livestock systems) needs time to manifest.

Development of sound decision support systems

In precision agriculture, scientifically and economically sound decision support systems are a major bottleneck. Therewith, a research focus should be on precise identification input utilisation factors and yield determining factors, their interaction, and their translation in crop management decision. In general, the relationship between generally valid rules and concrete site specific rules is of high relevance for input efficiency and improved site specific yield potentials.

Address different European farming systems

The European farming systems face different challenges and have specific potentials for sustainable intensification. This should be addressed specifically by agricultural research. Research activities should also include extensive farming and small-scale farming (e.g., semi-subsistence farming) in Europe, to preserve their contribution to food supply, to enhance their productivity and to sustain their environmental and social benefits.

For example, principle of site-specific application of production inputs should be made available for the different European farming systems. Therefore, “soft” PA concepts should be developed which depends mainly on inexpensive technologies or visual observation of crop and soil, and management decision based on experience and intuition. Open question is how high-tech and low-tech approaches could learn from each other.

Strengthening participatory research

For addressing the relevant challenges and encouraging local adoption, interdisciplinary and participatory research should be strengthened. For up-scaling of advanced crop production systems, is, new networks among diverse stakeholders are needed to combine top-down and bottom-up knowledge creation and transfer mechanisms, including institutional learning. This task has to be taken up by the scientific system as well as by funders. At European level, a network “Participatory Research for Global Food Security” could be established in the frame of the Horizon 2020 programme.

Boundaries of the past between public funded basic research and private funded applied research as well as between research institutes and universities as dominant sources of knowledge and innovation and the farmers and commercial sector as adopters get more and more blurred. This demands new forms of cooperation and knowledge exchange. Without public funded incentives for new cooperations, the agricultural knowledge system could become increasingly fragmented.

Revitalise public extension

Effective knowledge and technology transfer to the farming communities, using a combination of scientific and practical expertise, is of high importance. Public funded extension services should be revitalised to increase the skills and knowledge base of agricultural producers breadthwise.

Create incentive programmes

Support in the frame of agri-environmental measures should be implemented for crop production systems with an agro-environmental focus, because the conversion is often connected with initial investments, costs and risks of learning and adapting to local conditions, and delayed improved returns.

Start enabling CAP reform

The direct payments to farmers from the Pillar I of the CAP are neutral in regard to the applied crop production systems. A more enabling surrounding for sustainable intensification would demand a longer-term transformation of the CAP with a phasing out of direct payments, replaced by public payments linked to the provision of societal benefits. Difficulty is to achieve a broad consensus on agricultural production systems which are sustainable or on criteria for environmental-friendly production measures.

Link sustainable intensification with nutrition change

A wider spread of specific agricultural production systems (e.g., organic farming) could support the change of diets with lower consumption of meat products, therewith reducing the high land demand of animal production. Research should further investigate this link, and policies address this issue.

Strengthening plant breeding progress

In the past, plant breeding made a major contribution to increasing yields. In the coming years and decades, further progress is needed in plant breeding which addresses the challenges ahead and different farming systems. Public sector crop breeding and genomics programmes should be initiated that emphasis longer term objectives which cannot be expected from the private sector.

Main focus in public breeding research support should be on marker-assisted selection and SMART breeding as very promising breeding technologies. Additionally, hybrid breeding research remains of high importance and should focus on molecular basis of the heterosis effect and on identifying the best combinations of parental lines for creation of high-performing hybrids.

Organic breeding in the EU is still highly heterogeneous. Progress in organic breeding is needed so that organic farming can take part on overall increase of yield potentials. Modern breeding technologies should be assessed technologies in regard to their compatibility with the principles of organic farming. Strengthening of organic breeding could also be of relevance for other farming systems. Special regulation for the authorization of heterogeneous, locally well adapted varieties should be introduced, and gene sequences of traditional varieties should be excluded from patenting.

Participatory plant breeding was developed and deployed to better serve the needs of small-scale farmers in developing countries. Participatory plant breeding could be an approach to address European semi-subsistence farming which would need public support. Overall, closer collaboration of plant breeders and farmers could become more important in the future with mainstreaming of agro-ecological approaches and more local differentiation of crop management.

New plant breeding techniques (such as cisgenesis/intragenesis) are associated with legislative uncertainties of the GMO classification. Contrary opinions on the legal status are developing in science and society. Therefore, a broad dialogue should be initiated with the aim to clarify the legal status of new plant breeding techniques in the frame of the GMO regulation.

Concern is that the increasing number of patents on basic tools for genetic modification and marker-assisted breeding in the hand of a small number of companies will hinder plant breeding innovations. Therefore, the public and non-profit research sector should support initiatives to create platforms for open innovation, using open source approaches.

Reducing crop losses

Harvest and post-harvest losses are an important issue on the global level. Their reduction can contribute to the local as well as global food security. Food losses until the farm gate include handling at harvest and postharvest, storage, and transport and distribution by farmers. The amount of food losses is dependent from natural factors like climate, weather, crop biological characteristics and spread of pests, and on the development state of food supply chains, with their specific post-harvest technologies, marketing organization and existing infrastructure.

For reducing crop losses (particularly in developing countries and transition countries), awareness among farmers and the other actors in the food supply chain should be increased. Long-term strategies should be established by international bodies, national and regional authorities as well as non-governmental donor organisations. Strategies should be tailored to their nature and causes, to the affected crops and to beneficiaries and their socio-economic characteristics. Private and public research and development should focus on selection of cultivars resistant or less susceptible to pests, biopesticides (particular against fungal pest producing mycotoxins), and small scale technical equipment.

Next important point is the provision of methodological guidelines and training on good practices, tailored to particular crops (taking into account differences among cultivars), locality and human and financial capacities of beneficiaries (e.g., subsistence farmers, commercial farmers). Equally important is the exchange of experience among farmers and information flows along food supply chains as essential elements of crop losses programmes; similarly, horizontal and vertical cooperation is needed.

Marketing system should be improved by government and local authorities, to support the spread of promising technologies by functioning food supply chains. Incentives should be given for the development of rural markets in their specificities, supplementary to urban and export oriented food markets.

Finally, infrastructure such as roads and railways should be enhanced, but attention should also be paid to clean water supply, energy supply and ICT (internet, mobile phone).

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